On the Need for High-Resolution Imaging

Julianne Dalcanton
University of Washington

Nearby galaxies are a critical anchor for all extragalactic studies. However, the observations that provide this anchor are almost entirely limited by angular resolution. In massive galaxies, the stellar density is sufficiently high that only the very brightest stars can be distinguished from each other, even with HST. Only when the stellar density is very low, or the galaxy is very, very close, can we cleanly resolve neighboring stars, or distinguish individual stars from stellar clusters. These requirements limit observations to a very small volume of space, such that massive (but rare) galaxies are highly underpresented. Moreover, even in M31, *we cannot detect any but the very brightest stars in the bulge*. Thus, there are no observationally accessible spheroids, which are likely descendents of the majority of massive systems studied at high-z. Likewise, the massive stars in the Trapezium could not be resolved in M31, even with HST resolution, limiting studies of very high-mass star formation to the Milky Way.

When data is crowding limited, *the only way to increase the depth of photometry is through increasing the angular resolution.*. Longer exposure times or more sensitive detectors do *nothing* to increase the depth; instead, the depth is set entirely by the magnitude at which the maximum number of stars per arcsecond are packed onto the detector ($\sim$12 per arcsec^2 for ACS, and $\sim$2 per arcsec^2 for WFC3/IR). The image below demonstrates this using HST data in M31 to show how the magnitude limit of observations change as a function of radius in the galaxy, *for identical exposure times*. Data for WFC3/IR (red and orange), and ACS/WFC (purple and magnenta) are crowding-limited, such that the magnitude limit in the high-surface density bulge of M31 is 6 magnitudes fainter than in the outer disk; only the uncrowded WFC3/UVIS data (blue and navy) shows the constant depth expected for photon-limited observations of constant exposure time.

Thus, if we are ever to have any well-founded understanding of massive star formation and/or spheroids and massive galaxies in the Local Universe, we absolutely need to have facilities that offer an order of magnitude improvement in angular resolution, at the UV through NIR wavelengths where stars emit the bulk of their flux. It is extremely unlikely that a probe-class mission will ever surpass the resolution of HST, and thus the road map must include plans for a 10m-class flagship.